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The effects of public capital on the productivity of the Italian regions

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Abstract

This paper investigates on the role played by public capital in increasing the productivity levels in Italy. For the construction of the regional series for the public capital stock over the period 1996-2003, the study benefits from the use of the rich dataset on public expenditure, recently published by the Italian Ministry of Economy. We have estimated panel production functions with the inclusion of traditional factors and also intangible inputs like R&D expenditure, human capital and social capital. The results point out that public capital has a positive and significant effect on production. Moreover, the effects of all production factors vary considerably between the two macro-areas of the country, namely Centre-North and Mezzogiorno. More specifically, while private capital is more effective in the South, labour and public capital exhibits an elasticity much higher in the Centre-North with respect to the Mezzogiorno. The disaggregation of the public capital stock into economic categories indicates a significant different impact in the two macro-areas. When the analysis is carried out by distinguishing among government levels it turns out that the decentralized administrative bodies are much less efficient in the South in delivering public expenditure.

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1. Introduction

The role played by public capital is increasingly capturing the attention of academic researchers and policy makers. This is particularly evident within the European Union, where the main aim of the EU institutions is to encourage and support the integration process among the country members by fostering economic growth and by promoting development in the poorest regions.

Public investment is a strategic and relevant component of the total productive capital stock for a country and is a key element in the economic growth process. Therefore, it is becoming more and more crucial to assess rigorously the effects that public investment produce on the production level. In particular, the most relevant issues emerging from the past and current empirical debate are: (i) the measure of the whole effect on production due to an increase in the level of public capital stock; (ii) how the effect differs across the various areas of the country, in consideration also of the analysis horizon considered (short *vs* long run); (iii) which is the contribution of different kinds of infrastructure to the total effect on production; (iv) which is the degree of complementarity (or substitutability) between public capital and other production factors (private capital, human capital, social capital); (v) how the effectiveness of public investment depends on the level of government that actually provides the funding.

The economic literature has attempted to provide an answer to the previous issues (for a recent survey of the theoretical and empirical literature, see Romp and de Haan, 2005). However, the results are mixed; they vary considerably depending on the period considered, the country analysed and the empirical approach adopted. Among a vast set of studies we refer in particular to the original contribution by Aschauer (1989), followed by other studies applied to the United States: Munnell (1990), Garcia Milà and McGuire (1992), Holtz-Eakin (1994), Evans and Karras (1994). Similar studies have analysed other countries; for instance, De la Fuentes and Vives (1995), Garcia Milà and Marimon (1999), Moreno *et al* (2003) for Spain; Pina and St Aubyn (2005) for Portugal; Stephan (2003) for Germany; Kawaguchi *et al* (2005), Kataoka (2005) for Japan. For the case of Italy we can refer to the contributions by Picci (1999), Bonaglia *et al* (2000), Paci and Saddi (2002), Di Palma and Mazziotta (2003). It is worth remarking that the need of evaluating the effectiveness of public interventions have determined a fresh interest in the building of comparable public capital stocks series for both industrialised and developing countries (see Nourzad, 2000; Hurlin and Arestoff, 2006; Kamps, 2006).

According to the methodology adopted, the analyses on the effects of public infrastructure can be divided into three main groups: (1) the growth accounting approach is employed to measure the public capital contribution to total factor productivity; (2) the public capital contribution is assessed

by means of the reduction in production costs; (3) the public capital effects are assessed by the estimation of production function relationships (usually a Cobb-Douglas), which include a measure of public infrastructure among the other inputs.

The analysis presented in this paper fits in the latter approach and it is based on the estimation of Cobb-Douglas production functions over the period 1996-2003, which allow to identify clearly the contribution of each productive input included in the specification.

The main contribution of our study, in contrast with previous analysis for the Italian case, is represented by the use of the recent dataset "Regional Public Accounts" (Conti Pubblici Territoriali, CPT) made available by the Department for Development and Cohesion Policies of the Italian Ministry of Economy and Finance (last release, March 2006[1]). The dataset consists of the series of capital account public expenditure disaggregated by regions, levels of government and policy intervention measures.

The major limitation of previous works, not only to the Italian case, was actually represented by the unavailability of a clear and reliable estimate of the contribution of the public sector to the capital stock formation. Given the lack of data, the definition of public investment has often been confined to either the expenditure in physical infrastructure or to physical measure of specific infrastructure or to the Public Administration investments, thus leading to a severe underestimation of the role played by the public sector in the national economy. As a matter of fact, some important types of expenditures were overlooked or completed ignored, such as, for instance, government incentives to private firms investments across all production sectors and also expenditure by private bodies controlled by public administrations. On the contrary, for the first time in Italy, the CPT dataset allows to measure more accurately the economic contribution of the public sector since it considers all public institutions and also other bodies operating under the direct control of the public sector.[2] It is worth emphasising, however, that the short spell of time available (just 8 years) calls for a very cautious interpretation of the results provided, as they can be affected by the period considered. Moreover, the estimates obtained in this paper cannot be readily compared with previous results, which refer to different periods or are based on different methodologies.

The second important contribution of this paper to the existing literature is the inclusion in the production function (together with the traditional inputs like labour, private and public capital) stock) of other relevant inputs such as R&D expenditure, human capital and social capital. A growing number of studies has highlighted the importance of these "intangible" inputs to explain

[1] Note that this last version of the CPT dataset updates the series up to 2003 and includes a complete revision of the previously published data for the period 1996-2002.

[2] Some important examples of former public monopolies which became formally private companies but remain under the direct control of the government are: ENEL (the electrical national company), Società Poste Italiane (the national postal service), Ferrovie dello Stato (the national railway), ENI (the national energy company).

the levels and the dynamics of economic systems. The inclusion of the R&D expenditure in the production function has been originally suggested by Griliches (1979) and afterwards it has been used both at the firm and aggregate levels. The literature has emphasized the positive role of human capital on productivity level and its growth (Mankiw *et al.*, 1992) although the results are mixed (Benhabib and Spiegel, 1994). At the regional level it has been suggested that a higher availability of well educated labour forces represents an advantage for the localization of innovative firms thus promoting local productivity (Rauch, 1993). Another important element, often neglected by economists, which influences the productivity level is social capital (Coleman, 1990; Temple and Johnson 1998). The hypothesis is that a higher degree of social capital enhances the economic conditions of a certain area since it helps the diffusion of trust among agents (Diani, 2004), decreases the transaction costs for both firms and consumers and facilitates the diffusion of knowledge (Helliwell and Putnam, 1995).

In general, these "intangible" inputs are supposed to enhance the level of production by making the traditional physical inputs, such as labour and capital, more productive by creating a more favourable economic environment.

The paper is organized as follows. The methodology adopted for the reconstruction of the regional series of public capital stock for the aggregate, for four economic macro-sectors and for four different levels of government is discussed in Section 2. In section 3 we present the descriptive analysis of the most relevant variables. The results of the estimation of different production function specifications over the period 1996-2003 are discussed in section 4, while section 5 offers some concluding remarks.

2. Construction of the public capital series

As stated in the introduction, by building on the seminal contribution by Aschauer (1989), the aim of this study is to assess the impact of public intervention in the Italian economy by means of the estimation of Cobb-Douglas production functions in which the public capital stock is included along with the others inputs, such as labour, private capital and other variables which are expected to have a significant effect on the level of production.

The Italian National Institute of Statistics (ISTAT) does not publishes data on the capital stock series at regional level; moreover, for the country as a whole only data for the total capital stock is provided, without any disaggregation which takes into account the private or public origin of the funding. The only breakdown refers to the capital stock by economic activity branch, which is consistent with the National Accounts definitions. Therefore, the first stage of this study focused on

the construction of the capital stock series at regional level and subsequently the decomposition of the total capital series into the stock of private and public capital. Such a disaggregation is crucial in order to disentangle the effect on the production process due to the public sector intervention and the one due to private enterprises.

The reconstruction of the capital series (aggregate, private and public stock) has been carried out for the period 1996-2003. As matter of fact, the regional data on public buildings and infrastructures available from 1960 do not match the series published in the CPT database as the latter allow for a wider definition of the public expenditure in investments. Such expenditure includes not only the traditional funding for physical infrastructures, but also a number of interventions aimed to support other types of infrastructures (i.e. tourism, health and sanitation). Therefore, it has not been possible to reconstruct the series for a longer time span.

The capital stock series has been calculated by applying the perpetual inventory method, which states that the value of the capital stock at time *t* (in our study 1996) is equal to the value at time *t-1* (i.e. 1995), augmented by investment and diminished by depreciation, both measured at time *t*.

Although in empirical applications different definitions of capital have been adopted (gross capital stock, net capital stock, fixed capital consumption or gross fixed capital accumulation), we believe that the stock of net capital is an adequate definition as it allows to take into account the decreasing efficiency of the capital goods due to their utilization in the production process. It is worth noting that in the production function specification both output and labour are *flow* variables, while capital is a *stock* variable; this can affect the estimates as the series exhibit different dynamic features. However, given that a capital flow variable (such as capital consumption) is not available, the use of net capital - instead of gross capital - should alleviate the estimation problems (Bonaglia *et al*., 2000).

The capital stock for the year 1995 (i.e. the initial year on which the reconstruction of the series is based, but which will not be included in the estimation period) is represented by the datum provided by ISTAT for the national capital stock at 1995 constant prices. The partition of the national stock among the regions has been carried out by following the methodology proposed in Gleed and Rees (1979) for the British economy and also applied in Paci and Pusceddu (2000) for the Italian context. In particular, the regional subdivision is based on the regional average share of investments (weight 0.75) and labour units (weight 0.25) in the preceding 15 years. Total investments data for the subsequent period 1996-2002 are provided by ISTAT in the "Regional Economic Accounts" dataset. All the variables available at current prices are deflated by applying the regional implicit investment deflators.

The crucial key element in the methodology adopted is clearly the definitions of "public investments", which are represented by the capital account public expenditure of the entire public sector ("settore pubblico allargato") provided in the CPT database. In particular, in constructing the series we focused on the elements compatible with the National Accounts, namely "investment expenditure" and "capital account transfers"[3].

In this way we are allowing to include in the "public investment" aggregate not only the capital goods which are explicitly owned by public administrations or institutions, but also the portion of private investment which has been undertaken only thanks to the public funding in the form of firms' transfers. This wide definition of "public investments" allows, for the first time in Italy, to assess thoroughly the effects of public intervention in the economic system.

Given the definition of public investments, the private component has been obtained as the difference between total investments and public investments. The total depreciation published by ISTAT for the whole national stock of capital has been attributed to the public and the private component on the basis of the investment quotas. Note that for the period considered in this study, the depreciation, equal to 4% of the previous year capital stock, amounts to around 70% of gross investments. Such a relevant share of depreciation on gross investment means that on average net investment is just 2% of the total stock of capital.

Finally, the national total capital stock in the initial year 1995 has been disaggregated into its public and private components on the basis of the average shares in the subsequent years, 1996-2003. This amounts to assume implicitly that the composition of the aggregate stock do not change significantly in the period considered, so that the information embodied in the 1996-2003 data can be employed to calculate the public and private quotas in the initial year[4].

By applying the perpetual inventory method and the hypotheses outlined above we have also reconstructed the series for the regional public stock of capital over the period 1996-2003. Analogously, we have then obtained the series of the public capital stock disaggregated in four economic macro-sectors - economic infrastructures, human capital infrastructures, social infrastructures and housing - and into four levels of government - central public administration, the regional administrations, the local administrations and other central administrated public bodies.

In the next section we present a detailed description of the public capital series and of the other variables included in the production function estimations.

[3] We have therefore intentionally excluded all financial entries (i.e credits and share capital quotas).
[4] In order to assess the robustness of such an hypothesis we have also calculated the share of public capital on total capital stock as equal to the "Public Administration" sector, published in the ISTAT National Accounts. The results do not change appreciably, so the subsequent analysis is based on the methodology described above.

Finally, it is worth underlining that the perpetual inventory method, which allows calculating the monetary value of the capital account public expenditure, may present some drawbacks. It is often argued that public expenditure is not completely "transformed" into the productive infrastructures actually utilized in the economic system; this can lead to overestimating the capital stock in those regions which are less efficient in the use of public funds. An alternative approach implemented in order to assess the impact of public capital in enhancing production is the one which considers indices of the realized physical infrastructures (Bracalente *et al.* 2005). However, such an approach turns out to be inadequate if the interest is on measuring the effectiveness of the whole capital account expenditure of the entire public sector[5]. In order to obtain a comprehensive estimate of the impact of public capital it is crucial to take into account all public resources, which have not only been directly transformed into a physical infrastructure, but - in the form of financial incentives to firms - have also created the conditions to start a new private investment. It is indeed only the broad definitions of the CPT capital account series that allow to assess how production and efficiency enhancing is the public sector intervention in the Italian economic system.

3. Data analysis

In this section we describe the series used in our empirical analysis. In table 1 we report some summary indices of the variables included in the estimation of the production function specifications for Italy over the period 1996-2003. The entries refer to the Italian regions[6], to two macro-areas, namely Centre-North, Mezzogiorno (the Southern regions of the country[7]) and to the national aggregate. All the values are calculated as index numbers with respect to the national average (Italy=100). In the first part of the table we show the per capita values for gross domestic product, research and development (R&D), human capital and social capital, while the second part of the table reports the share of public over total capital stock and some summary measures for the public stock of capital, namely index numbers for per capita, per unit of labour and per square kilometre values.

From the per capita GDP data it is evident (second column of table 1) that all the Mezzogiorno regions are well below the national average, confirming the permanent economic divide between the Centre-Northern and the Southern parts of the country; it is worth noting that during the period 1996-2003 the Mezzogiorno has grown at an average annual rate of 2%, which is higher with

[5] Note also that physical measures of the public stock of capital are not available on a time series basis.
[6] In this study the region of Val d'Aosta is aggregated to Piemonte, as for its very small size it often exhibits peculiar values.
[7] The regions included in the Mezzogiorno aggregate are: Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna.

respect to the Centre-North rate of 1.4%; however, much higher and persisting growth rates would be required in the Southern region to fill the gap in per capita GDP.

The three subsequent columns report index numbers for three important inputs to be included in the production function regressions, namely R&D, human capital and social capital proxies.

The R&D proxy is represented by the number of workers employed in research and development activities for 1000 inhabitants; the human capital variable is proxied by the percentage of workers that have attained at least a university degree ("laurea"). The choice of a proper indicator for an intangible and complex element like social capital is a very difficult task. In this paper we are using an indicator taken by an annual social survey held by ISTAT (Indagine multiscopo) defined as the number of people (per 100 inhabitants over 14 years old) that have taken part at least once in the last twelve months in social activities such as voluntary service, unions and cultural associations meetings [8].

Human capital does not show relevant differences between the Centre-Northern and the Southern regions as the annual averages are quite close to the national one. On the other hand, the R&D and the social capital proxies show a clear dualistic pattern across the regions. In the case of R&D the Mezzogiorno average is about half of the national one, while the Centre-North has an average which is 26% higher with respect to the country one and 2.4 times as higher as the Southern one. The social capital shows a less dramatic difference, but the gap between the Mezzogiorno and the Centre-North is still highly significant, as the two areas are 44 percentage points apart.

Considering the crucial role that intangible infrastructures, such as human capital, social capital and R&D activity play in enhancing the development process and in reducing the gap between poor and prosperous regions, the data discussed above are particularly worrying and call for prompt and decisive policies capable of modifying permanently the current pattern, an unequivocal cause/consequence of the Italian dualistic growth dynamics.

Before turning to the analysis of public capital data, it is important to highlight that the accumulation of the total stock of capital has grown much rapidly in the Centre-North (2.1% on average) than in the Southern regions, where the annual growth rate was just 1.7% over the period 1996-2003. Table 1 highlights an important point, the public component of the total stock of capital is much more relevant in the Mezzogiorno, where it reaches a share of 39.1%, which contrasts sharply with the Centre-North share of 23.4%; four Southern regions out of eight show a share higher than 40%, namely Basilicata (61.3%), Sardegna (49.9%), Molise (49.2%), and Calabria

[8] Alternatively, as a social capital proxy we have also considered the "political participation" (measured as number of people that have take part at least once in the last twelve months in political associations events) and the "crime risk perception rate" (measured as the proportion of families that consider the area in which they live as insecure). The inclusion of these alternative proxies for social capital did not change appreciably the regression results presented below.

(44.4%). In the case of Lazio – where all the Ministries and most of the central administrations have their headquarters - it is important to note that part of the public capital stock attributed to this region might reasonably be due to public investment that cannot be regionalized.

Focusing on the public stock of capital, the per capita value and the unit of labour value are higher in the Mezzogiorno when compared to the national average, this, *ceteris paribus* and excluding crowding out effects, is expected to lead to higher labour productivity.

The following tables 2-3 show the percentage shares of the different kinds of infrastructures and levels of government in which the total stock of public capital can be decomposed. The four kinds of infrastructures are economic infrastructures (transport, telecommunications, environment, waste, water, energy, agriculture, fishing, industry, tourism and other services), human capital infrastructures (buildings and facilities for education, training, R&D, work and social security); social infrastructures (buildings and facilities for cultural activities, health services, sanitation, defence, justice administration, public security and general administration) and housing.

As shown in the second column of table 2, economic infrastructures are the most relevant public capital component, with a share of 65% for the national aggregate, which increases considerably in the Mezzogiorno (67.6%). The regions with the highest share for economic infrastructures are Molise (70%), Basilicata (69.5%), Liguria (69.3%), followed by Puglia (68.8%) and Sicilia and Sardegna (both 68%). In the Mezzogiorno higher shares are also associated with the "housing" component (9.1% with respect to 8% in the Centre-North). Noticeable exceptions are represented by Umbria (17.6%), Friuli Venezia Giulia (10.9%) and Marche and Campania (both 10.5%). On the other hand, the Southern regions show lower shares for both human capital and social capital kind of infrastructures. The former exhibits a share of 7.7% in the South, while in the Centre-North the share is 8.5%. The region with the highest share of human capital infrastructures is Lazio (10.4%), followed by Lombardia (9.5%) and Toscana (9.2%); the lowest shares are those of Umbria (5.9%), Liguria and Basilicata (both 6.1%). Only as small proportion as 15.5% of the Mezzogiorno public capital is constituted by social infrastructures, the value increases to 20.4% for the Centre-North, where we found the region with the highest share, Veneto (25.7%), while Puglia shows the lowest one, just 14.5%.

The data on human capital and social capital infrastructures mirror the patterns discussed above for their "intangible" counterparts; therefore, it seems necessary to complement the policies designed to support the quick accumulation of human and social capital with an increase in the level and effectiveness of public investments for infrastructures in the same fields.

Finally, in table 3 we report the percentage shares of the public stock of capital for the four different types of administrations which deliver the funds. As expected the central State

administration is the most relevant one for all the Mezzogiorno regions with share of 32.2%. The regional administration shows a similar pattern with a Mezzogiorno share of 19% and a Centre-North one of just 14.4% (national share 16.3%). On the other hand, the local administrations exhibit a reversal composition with an higher share in the Centre-North (30.7%) with respect to the Mezzogiorno (25.7%). The other central administrated public bodies have a national average of 29.2%, which turns out to rise considerably in the Centre-North (33.5%) with respect to the South (23%).

4. Production function estimations for Italy and the macro regions

The effects of public investment in Italy over the period 1996-2003 are assessed by means of estimating Cobb-Douglas production function specifications. The empirical analysis is articulated by considering different decompositions for the total stock of capital.

4.1 Total capital stock

In the first specification, which is the simplest one, the capital input is considered in the aggregate:

$$Y_{it} = A_i L_{it}^{\alpha} K_{it}^{\beta} \prod_{j=1}^{J} X_{j,it}^{\gamma_i} \qquad (1)$$

where Y is regional value added in 1995 base constant prices (excluding the financial intermediation services), L are units of labour, K is the stock of capital; X is a set of J control variables, in our study these are represented by the "intangible" inputs, namely research and development (*RD*), human capital (*HK*) and social capital (*SK*). The subscript i indicates the region, while t refers to the time period. A represents the efficiency level; the parameters α e β are the output elasticities with respect to each of the traditional inputs, while the γ_k coefficients measure the impact of the intangible inputs.

By taking logs, equation (1) is transformed in the following estimation model:

$$y_{it} = a_i + \alpha l_{it} + \beta k_{it} + \gamma_1 rd_{it} + \gamma_2 hk_{it} + \gamma_3 sk_{it} + \varepsilon_{it} \qquad (2)$$

Model (2) is estimated by employing a panel of 19 regions and 8 annual observations over the period 1996-2003; this can be considered a "small" panel, since both the cross-section and the time dimension are rather short. In this case the estimation results have to be interpreted very cautiously.

Due to panel dimension in the estimated regression we do not include regional fixed effect, but an additive and a multiplicative dummy variable "South", which is supposed to capture the time-

invariant different characteristics of the Centre-North and the Mezzogiorno macro-areas. We also include time dummies and a dummy "Lazio", which should offset the effects of the non-regionalized funds. All the estimation results are presented in table 4, to ease the comparisons in table 5 we report the results for the two macro-regions separately.

The first column shows the estimation results for the regression model (2) without including the additive and multiplicative dummy "South", so that this model can be seen as a sort of *national benchmark* which allows to assess regional differences in the estimated input elasticities. According to specification (1) the elasticity of labour is around 0.84, while the total stock of capital exhibits an elasticity of 0.18. The labour estimate is higher, while the capital stock one is lower if compared to previous study for the Italian case (Picci, 1999, La Ferrara and Marcellino, 2000). Innovation activity and social capital show elasticities estimated in 0.10 and 0.08, respectively. In the case of human capital the estimate obtained (0.0003) is a semi-elasticity as it measures the percentage increase in output due to an increase of 1 percentage point in the proportion of graduate workers. It is worth stressing that - with the exception of human capital - the "intangible" factors exhibit a positive and significant coefficient, confirming their relevant contribution to the production process.

In specification (2) the dummy "South" is included to assess for the existence of differences in the effect of production factors between northern and southern regions. Note that only significant estimates are reported and discussed. For this specification only labour exhibits an elasticity (0.66) homogeneous across the country macro-areas; the elasticity of the total stock of capital decreases significantly from the Centre-North values of 0.39 to the Mezzogiorno one of 0.32; a similar result is found for the social capital input as well, the estimated impact is 0.027 for the Centre-Northern macro-area and -0.049 for the South; note that the social capital impact appear to have even an adverse effect on the South production level. On the other hand, human capital (0.007 in the Centre-North versus 0.012 in the Mezzogiorno) and R&D (0.035 vs 0.057) turn out to be more productive in the Southern part of the country.

4.2 Specification including private and public capital stock

In specification (3) we introduce the disaggregation of the stock of capital into its private (k^{pr}) and public (k^{pu}) components:

$$y_{it} = a + \alpha l_{it} + \beta_1 k_{it}^{pr} + \beta_2 k_{it}^{pu} + \gamma_1 rd_{it} + \gamma_2 hk_{it} + \gamma_3 sk_{it} + dummies + \varepsilon_{it} \qquad (3)$$

This specification is crucial in order to estimate the effect of the public stock of capital on the country productivity. As discussed above, also in this case we include the additive and multiplicative dummy "South" in order to assess thoroughly the disparities between the Centre-

Northern and the Southern areas, which can lead to misspecification problems if they are overlooked.

From specification (3) it is important to highlight the significant positive sign associated with the public capital stock which confirms the results of the previous literature on the positive role played by the public expenditures on the production level. Looking at the territorial differences it is worth noting that thee estimated elasticity of public capital is significantly higher in the Centre-North (0.15) with respect to the Mezzogiorno (0.12). Note also that both values are lower compared to previous analyses (Picci, 1999; La Ferrara and Marcellino, 2000; Marrocu *et al*., 2001; Paci and Saddi, 2002); however, it is worth keeping in mind that such studies focused on periods characterised by a very speed process of capital accumulation, especially in the Mezzogiorno.

Turning to the other productive inputs, it is evident that their impact differs considerably when the geographic pattern is accounted for. In particular, the labour is much less productive in the South (the estimated elasticity decreases from the Centre-North value of 0.76 to the value of 0.49 for the South). On the other hand, the private capital stock turns out to be twice more productive in the Mezzogiorno. Focusing on the "intangible" inputs, the R&D variable shows an elasticity much higher in the South (0.054) than in the Centre-North (0.022); this is presumably due to the fact that in the Mezzogiorno there is just half of the employees in the R&D sector with respect to the national average. On the contrary, human capital and social capital show a significant negative impact in the South. In the case of human capital this result might be due to the fact that in Southern regions a considerable proportion of the graduated labour force holds a degree in fields such as humanities or law, which are supposed to have a limited effect on production; on the other hand, in the Centre-North there is evidence of a greater proportion of workers with a degree in scientific and technological fields (engineering, science, medicine, informatics). The negative impact of social capital – consistently found in the other specifications as well – is reasonably capturing the lower level of general trust and confidence in the South, which is suppose to have a severe adverse effect on the firms' investment and location decisions.

4.3 Public capital stock disaggregated into macro-sectors

In this section we discuss the results obtained when the stock of public capital is disaggregated according to different kinds of infrastructure or macro-sector of public intervention. We recall that the reconstruction of the public capital stock has been carried out for four sub-aggregates, namely economic infrastructures, human capital infrastructures, social capital infrastructures and housing. However, in order to simplify the analysis the last three typologies of public capital (which on average sums up to 35% of total public capital) have been grouped together.

Specification (4) confirms the previous results with the labour factor showing a lower elasticity in the Mezzogiorno (0.62 vs 0.80), while the private capital stock elasticity is lower in the Centre-North (0.14 vs 0.28).

The stock of public capital exhibits quite different elasticities for the two categories considered and for the two macro-areas of the country. More specifically, the economic infrastructures, which account for the largest proportion of the public stock, are much more productive in the Mezzogiorno (0.235) compared to the rest of the country (0.10). In contrast, all the other types of public interventions show a negative impact in the Mezzogiorno (-0.051) and a low one in the Centre-North (0.013). These results are of great interest as they highlight the beneficial impact of the most production-oriented kind of infrastructures in the Southern regions and emphasize the need to focus even more on public policies intended to tackle the productive structure of the economic system; Such policies should designed to guarantee at the same time an increased level of the national production and a permanent reduction in the regional disparities.

For this particular specification, the R&D impact in the South (0.081) is almost three times as large as the one for the Centre-North (0.028); this result can be interpreting considering the low proportion of R&D workers in the South, which can yield to increasing returns to this specific factor. The human capital coefficient turns out to be constant all over the country with an estimated semi-elasticity of 0.005. Social capital, on the other hand, continues having a quite negative effect (-0.069) in the Mezzogiorno, while it turns out to enhance production levels in the Centre-North.

4.4 Public capital stock disaggregated into levels of government

The results shown in the last column of table 4, obtained from the estimation of production function relationship where the stock of public capital is disaggregated according to levels of government, allow assessing the efficiency of the different administrations in charge for the delivering of public funds.

In order to simplify the econometric analysis the four kinds of administration have been grouped into two main categories: the central level (central administration and the other central administered public bodies) and the decentralized level (regional and local administrations).

Specification (5), by providing further evidence on how the inputs' impacts differ across macro-regions, supports the previous results regarding the estimated effects for labour (lower in the Mezzogiorno), private capital (lower in the Centre-North), R&D (higher in the Mezzogiorno) and social capital (negative in the Mezzogiorno).

As far as the public capital stock is concerned, it is important to highlight that in the Mezzogiorno the regional and local administrations are much less efficient in delivering public

funds, as the estimated elasticities turns out to be nearly three times lower with respect to the Centre-North (0.021 vs 0.059). Central administrations, on the other hand, exhibit the same degree of efficiency across the macro-areas.

The very low value estimated for the South is rather worrying as it signals the incapacity of the local governments of exploiting the informative advantages due to the proximity to the economic and social structure; such advantages are expected to make more effective the beneficial impacts of public investments in the poorest regions of the country.

5. Conclusions

This study aims to evaluate the effects of public capital stock on the level of production. Such an assessment is rather relevant considering the crucial role played by public investments in Italy and Europe to enhance economic growth and development, in particular in the poorest regions. The economic resources devoted to increase the physical and intangible infrastructure endowment are an important component of the national stock of capital and are a key factor for economic growth.

The effects of the public capital stock have been measured by estimating production functions relationships in which it is included among the other productive inputs, such as labour and private capital stock. The series of public capital – and their disaggregation into different infrastructure components or according to various government levels delivering the funds – have been reconstructed by using the data on capital account public expenditure of the recently published CPT database (Department for Development and Cohesion Policies of the Italian Ministry of Economy and Finance).

For the first time in Italy, on the basis of the CPT database it is possible to obtain a comprehensive and reliable estimate of the contribution of the whole public sector to the accumulation of the national stock of capital (up to now for the lack of data it has necessarily been limited to physical infrastructures or to the Public Administration investments). Moreover, the CPT series allow describing a complete picture of the public investment expenditures delivered by all public institutions, or by institutions operating within a public context and, at the same time, to measure more accurately the contribution of the public sector to the economic growth process at regional level. However, it is worth noting that the short period of time available (just 8 years) calls for a very cautious interpretations of the results provided, as they can be affected by the period considered. Moreover, the estimates obtained in this paper cannot be readily compared with previous results, which refer to different periods or are based on different methodologies.

Once one controls for the effects of intangible inputs (R&D, human and social capital), the results obtained from the estimation of Cobb-Douglas production functions for Italy over the period 1996-2003, highlight unequivocally the positive role played by the public capital stock in fostering the level of production. Although the estimated elasticity is lower compared to previous studies for the Italian case, it is important to stress that even in the most recent years when the speed of capital accumulation has considerably decreased, the public intervention in still a key factor in determining the country production level.

The second relevant point concerns the different impact that the productive inputs have on the economy of the two macro-areas of the country, thus providing further evidence on the dualistic character of the national economic structure. In particular, the results show that while labour is less productive in the South, private capital has a lower impact in the Centre-Northern regions.

The analysis of the effects of the stock of public capital is further articulated by considering its different components and the disaggregation into levels of government. The most relevant results point out that economic infrastructures are much more productive in the South, while the other types of public infrastructure seem to play a very limited role. This result call for even greater efforts in implementing and designing policies aimed at increasing the national level of production and, at the same time, at reducing the regional disparities permanently.

The disaggregation of the public capital into levels of government led to the conclusion that in the Mezzogiorno the regional and local administrations are much less efficient in delivering public funds; the very low value estimated for the South is rather worrying as it signals the failure of the local governments in exploiting the informative advantages due to the proximity to the economic and social structure in order to make more effective the beneficial impacts that public investments are expected to produce in the poorest regions of the country.

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Table 1 – Descriptive Statistics, Indices *(Italy=100, average values 1996-2003)*

	Per capita GDP[1]	R&D[2]	Human capital[3]	Social capital[4]	Share of public stock on total stock	Public capital stock		
						per capita	per labour unit	per km^2
Piemonte+Val D'Aosta	116	156	87	102	21.7	87	79	69
Lombardia	130	129	103	121	16.8	69	59	138
Liguria	108	116	115	87	38.2	152	150	236
Trentino A.A.	131	69	72	249	40.2	210	165	76
Veneto	117	67	82	151	17.3	65	56	84
Friuli V. G.	114	116	93	139	31.2	138	124	109
Emilia R.	126	127	103	122	20.5	80	65	75
Toscana	110	101	94	110	25.4	88	78	70
Umbria	97	93	101	103	32.9	112	110	58
Marche	101	62	98	96	25.0	88	81	70
Lazio	110	205	137	70	30.1	121	117	192
Abruzzo	86	87	101	75	36.8	127	136	79
Molise	79	29	96	83	49.2	191	222	74
Campania	64	67	100	63	39.1	111	150	246
Puglia	66	42	93	77	30.2	78	98	85
Basilicata	72	41	75	80	61.3	219	280	69
Calabria	62	22	105	72	44.4	127	169	90
Sicilia	67	52	102	62	35.7	101	140	104
Sardegna	76	59	82	105	49.9	172	202	62
Centre-North	118	126	101	115	23.4	92	82	100
Mezzogiorno	68	53	97	71	39.1	114	148	101
Italy	100	100	100	100	28.0	100	100	100

[1] *GDP*, *population* and *labour units* are from the CRENoS database on the Italian regions

[2] *R&D* is defined as the number of workers employed in R&D activities for 1000 inhabitants (*source*: ISTAT, Statistics on the Scientific Research).

[3] *Human capital* is defined as the percentage of the labour force that has attained at least a degree, (*source*: ISTAT, Labour force survey).

[4] *Social capital* is defined as the number of people that have take part at least once in the last twelve months in social activities such as voluntary service, unions and cultural associations meetings (*source*: ISTAT, Multiscopo survey).

Table 2 – Public capital stock per macro-sectors
(percentage values, average values 1996-2003)

	Economic infrastructures	Human capital infrastructures	Social infrastructures	Housing
Piemonte+Val D'Aosta	65.1	8.1	20.7	6.1
Lombardia	61.4	9.5	20.7	8.4
Liguria	69.3	6.1	16.7	7.9
Trentino A.A.	59.3	8.2	24.1	8.5
Veneto	60.0	7.0	25.7	7.3
Friuli V. G.	60.8	7.1	21.2	10.9
Emilia R.	62.6	7.8	23.1	6.4
Toscana	63.5	9.2	20.3	7.0
Umbria	57.0	5.9	19.5	17.6
Marche	57.8	7.0	24.7	10.5
Lazio	66.5	10.4	15.5	7.6
Abruzzo	63.6	9.0	18.4	9.0
Molise	70.3	8.5	15.2	6.0
Campania	67.2	7.8	14.6	10.5
Puglia	68.8	7.6	14.5	9.2
Basilicata	69.5	6.1	16.6	7.9
Calabria	67.3	8.3	15.3	9.1
Sicilia	68.0	7.8	15.0	9.2
Sardegna	68.0	7.0	17.7	7.2
Centre-North	63.1	8.5	20.4	8.0
Mezzogiorno	67.6	7.7	15.5	9.1
Italy	65.0	8.2	18.4	8.5

Table 3 – Public capital stock per levels of government
(percentage values, average values 1996-2003)

	Central Administration	Regional Administration	Local Administration	Other central administerd public bodies
Piemonte+Val D'Aosta	20.9	18.1	30.6	30.4
Lombardia	20.4	12.4	35.4	31.8
Liguria	25.0	8.7	30.4	36.0
Trentino A.A	4.7	50.3	33.3	11.7
Veneto	20.2	15.7	34.9	29.2
Friuli V. G.	15.3	22.8	31.4	30.5
Emilia R.	18.1	13.4	30.5	38.0
Toscana	18.2	11.3	32.7	37.8
Umbria	26.6	15.3	36.5	21.7
Marche	19.0	16.7	35.7	28.6
Lazio	31.2	4.0	20.4	44.3
Abruzzo	30.8	16.9	23.1	29.2
Molise	33.1	24.8	25.7	16.4
Campania	36.0	10.7	28.1	25.2
Puglia	39.1	11.3	25.5	24.1
Basilicata	34.1	19.9	22.8	23.2
Calabria	36.2	23.4	22.8	17.6
Sicilia	26.0	23.5	27.1	23.4
Sardegna	23.6	33.8	23.8	18.9
Centre-North	21.3	14.4	30.7	33.5
Mezzogiorno	32.2	19.0	25.7	23.0
Italy	25.8	16.3	28.6	29.2

Table 4 Estimation of the production function for Italy

Dependent variable: value added at 1995 constant prices
Method: GLS (Cross Section Weights)
Sample: 1996 2003; Included observations: 8; Number of cross-sections used: 19
Total panel (balanced) observations: 152; *standard errors* in parentheses

Regressors	(1)	(2)	(3)	(4)	(5)
constant	2.220 [a]	1.235 [a]	1.668 [a]	1.972 [a]	1.918 [a]
	(0.132)	*(0.098)*	*(0.127)*	*(0.118)*	*(0.135)*
labour	0.838 [a]	0.664 [a]	0.758 [a]	0.797 [a]	0.815 [a]
	(0.021)	*(0.019)*	*(0.031)*	*(0.030)*	*(0.034)*
total capital stock	0.184 [a]	0.386 [a]			
	(0.023)	*(0.020)*			
- private capital stock			0.171 [a]	0.142 [a]	0.084 [a]
			(0.030)	*(0.030)*	*(0.031)*
- public capital stock			0.150 [a]		
			(0.011)		
• economic infrastructures				0.096 [a]	
				(0.016)	
• other infrastructures				0.013 [a]	
				(0.008)	
• central administr. capital					0.045 [a]
					(0.005)
• regional and local administr. capital					0.059 [a]
					(0.005)
R&D	0.103 [a]	0.035 [a]	0.022 [a]	0.028 [a]	0.007
	(0.005)	*(0.008)*	*(0.008)*	*(0.008)*	*(0.010)*
human capital	0.0003	0.007 [a]	0.005 [b]	0.005 [a]	0.006 [a]
	(0.002)	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*
social capital	0.080 [a]	0.028 [a]	0.016 [c]	0.026 [a]	0.033 [a]
	(0.008)	*(0.008)*	*(0.008)*	*(0.008)*	*(0.012)*
dummy South		0.761 [a]	--	--	--
		(0.081)			
South*(labour)			-0.267 [a]	-0.181 [a]	-0.295 [a]
			(0.019)	*(0.019)*	*(0.020)*
South*(total capital stock)		-0.063 [a]			
		(0.005)			
- South*(private capital stock)			0.200 [a]	0.136 [a]	0.247 [a]
			(0.022)	*(0.019)*	*(0.019)*
- South*(public capital stock)			-0.031 [b]		
			(0.015)		
• South*(economic infrastructures)				0.139 [a]	
				(0.034)	
• South*(other infrastructures)				-0.065 [a]	
				(0.013)	
• South*(central administration capital)					--
• South*(regional + local administration capital)					-0.037 [a]
					(0.007)
South*(R&D)		0.022 [b]	0.032 [a]	0.052 [a]	0.043 [a]
		(0.010)	*(0.009)*	*(0.009)*	*(0.010)*
South*(human capital)		0.005 [b]	-0.010 [a]	--	-0.009 [a]
		(0.002)	*(0.003)*		*(0.003)*
South*(social capital)		-0.077 [a]	-0.068 [a]	-0.095 [a]	-0.076 [a]
		(0.014)	*(0.016)*	*(0.015)*	*(0.017)*

Note: dummy "South" assumes value 1 for the eight Southern regions and 0 for the remaining regions; time dummies and a dummy for the Lazio region are included in all specifications.
Significance levels: a = 1%, b=5%, c=10%

Table 5 Estimated coefficients of the production function for Italian macro-regions

Dependent variable: value added at 1995 constant prices; 1996-2003			
Specification	Regressors	Centre-North	Mezzogiorno
(2)	constant	1.235	1.995
	labour	0.664	0.664
	total capital stock	0.386	0.323
	R&D	0.035	0.057
	human capital	0.007	0.012
	social capital	0.027	-0.049
(3)	constant	1.668	1.668
	labour	0.758	0.491
	private capital stock	0.171	0.371
	public capital stock	0.150	0.119
	R&D	0.022	0.054
	human capital	0.005	-0.005
	social capital	0.016	-0.052
(4)	constant	1.972	1.972
	labour	0.797	0.616
	private capital stock	0.142	0.278
	public capital stock		
	• econ. infrastructures	0.096	0.235
	• other infrastructures	0.013	-0.051
	R&D	0.028	0.081
	human capital	0.005	0.005
	social capital	0.026	-0.069
(5)	constant	1.918	1.918
	labour	0.815	0.520
	private capital stock	0.084	0.331
	public capital stock		
	• central administrations	0.045	0.045
	• regional and local administrations	0.059	0.021
	R&D	0.007*	0.050
	human capital	0.006	-0.003
	social capital	0.033	-0.043
Time dummies and a dummy for the Lazio region are included in all specifications.			

The effects of public capital on the productivity of the Italian regions

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Abstract

This paper investigates on the role played by public capital in increasing the productivity levels in Italy. For the construction of the regional series for the public capital stock over the period 1996-2003, the study benefits from the use of the rich dataset on public expenditure, recently published by the Italian Ministry of Economy. We have estimated panel production functions with the inclusion of traditional factors and also intangible inputs like R&D expenditure, human capital and social capital. The results point out that public capital has a positive and significant effect on production. Moreover, the effects of all production factors vary considerably between the two macro-areas of the country, namely Centre-North and Mezzogiorno. More specifically, while private capital is more effective in the South, labour and public capital exhibits an elasticity much higher in the Centre-North with respect to the Mezzogiorno. The disaggregation of the public capital stock into functional categories indicates a significant different impact in the two macro-areas. In addition, when the analysis is carried out by distinguishing among government levels it turns out that the decentralized administrative bodies are much less efficient in the South in delivering public expenditure.

JEL: D24, H54, O47, R11, C23,
Keywords: public capital, production function, regional disparities, Italy

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1. Introduction

The role played by public capital is increasingly capturing the attention of academic researchers and policy makers. This is particularly evident within the European Union, where the main goal of the EU institutions is to encourage and support the integration process among the country members by fostering economic growth and by promoting development in the poorest regions.

Public investment is a strategic and relevant component of the total productive capital stock for a country and is a key element in the economic growth process. Therefore, it is becoming more and more crucial to assess rigorously the effects that public investment produce on the production level. In particular, the most relevant issues emerging from the past and current empirical debate are: (i) the measure of the whole effect on production due to an increase in the level of public capital stock; (ii) how the effect differs across the various areas of the country, in consideration also of the time horizon considered (short *vs* long run); (iii) which is the contribution of different kinds of infrastructure to the total effect on production; (iv) which is the degree of complementarity (or substitutability) between public capital and other production factors; (v) how the effectiveness of public investment depends on the level of government that actually provides the funding.

The economic literature has attempted to provide an answer to the previous issues (for a recent survey of the theoretical and empirical literature, see Romp and de Haan, 2005). However, the results are mixed; they vary considerably depending on the period considered, the country analysed and the empirical approach adopted. Among a vast set of studies we refer in particular to the original contribution by Aschauer (1989), followed by several other studies applied to the United States: Garcia Milà and McGuire (1992), Holtz-Eakin (1994), Evans and Karras (1994). Similar studies have analysed other countries; for instance, Flores de Frutos *et al* (1998), Moreno *et al* (2003) for Spain; Pina and St Aubyn (2005) for Portugal; Stephan (2003) for Germany; Thangavelu and Owyong (2000) for Japan, Bosca *et al.* (2004) for Australia. For the case of Italy we can refer to the contributions by Picci (1999), Bonaglia *et al* (2000), Paci and Saddi (2002), Destefanis and Sena (2005). It is worth remarking that the need of evaluating the effectiveness of public interventions have determined a fresh interest in the building of comparable public capital stocks series for both industrialised and developing countries (see Nourzad, 2000; Miller and Tsoukis, 2001; Hurlin and Arestoff, 2006; Kamps, 2006).

According to the methodology adopted, the analyses on the effects of public infrastructure can be divided into three main groups: (1) the growth accounting approach is employed to measure the public capital contribution to total factor productivity; (2) the public capital contribution is assessed

by means of the reduction in production costs; (3) the estimation of production functions (usually a Cobb-Douglas) is used to assess the effects of public capital together with other inputs.

The analysis presented in this paper fits in the latter approach and it is based on the panel estimation of Cobb-Douglas production functions over the period 1996-2003 for the Italian regions, which allow to identify clearly the contribution of each productive input included in the specification.

The main contribution of our study, in contrast with previous analysis for the Italian case, is represented by the use of the recent dataset "Regional Public Accounts" (Conti Pubblici Territoriali, CPT) made available by the Department for Development and Cohesion Policies of the Italian Ministry of Economy and Finance. The dataset consists of the series of capital account public expenditure disaggregated by regions, levels of government and policy intervention measures.

The major limitation of previous works, not only to the Italian case, was actually represented by the unavailability of a clear and reliable estimate of the contribution of the public sector to the capital stock formation. Given the lack of data, the definition of public investment has often been confined to either the expenditure in physical infrastructure or to physical measures of specific infrastructure or to the Public Administration investments, thus leading to a severe underestimation of the role played by the public sector in the national economy. As a matter of fact, some important types of capital expenditures were overlooked or completed ignored, such as: public investments in tourism, health and sanitation; government incentives to private firms investments across all production sectors; expenditures by private bodies directly controlled by public administrations. On the contrary, for the first time in Italy, the CPT dataset allows to measure more accurately the economic contribution of the public sector as a whole since it considers all public institutions and also other bodies operating under the direct control of the public sector.[1]

The second important contribution of this paper to the existing literature is the inclusion in the production function (together with the usual inputs like labour, private and public capital stock) of other relevant factors such as R&D expenditure, human capital and social capital. A growing number of studies has highlighted the importance of these "intangible" inputs to explain the levels and the dynamics of economic systems. The inclusion of the R&D expenditure in the production function has been originally suggested by Griliches (1979) and afterwards it has been used both at the firm and aggregate levels. As for the human capital, the literature has emphasized its positive role on productivity level and growth (Mankiw *et al.*, 1992) although the results are mixed (Benhabib and Spiegel, 1994). At the regional level it has been suggested that a higher availability

[1] Some important examples of former public monopolies which became formally private companies but remain under the direct control of the government are: ENEL (the electrical national company), Società Poste Italiane (the national postal service), Ferrovie dello Stato (the national railway), ENI (the national energy company).

of well educated labour forces represents an advantage for the localization of innovative firms thus promoting local productivity (Rauch, 1993). Another important element, often neglected by economists, which influences the productivity level is social capital (Coleman, 1990; Temple and Johnson 1998). The hypothesis is that a higher degree of social capital enhances the economic conditions of a certain area since it helps the diffusion of trust among agents (Diani, 2004), decreases the transaction costs for both firms and consumers and facilitates the diffusion of knowledge (Helliwell and Putnam, 1995). In general, these "intangible" inputs are supposed to enhance the level of production by making the traditional physical inputs, such as labour and capital, more productive because they create a more favourable economic environment.

It is worth emphasising that the short spell of time available (just 8 years) calls for a cautious interpretation of our results, as they can be affected by the period considered. Moreover, the estimates obtained in this paper cannot be readily compared with previous results, which refer to different periods or are based on different methodologies.

The paper is organized as follows. The methodology adopted for the reconstruction of the regional series of public capital stock for the aggregate, for four economic macro-sectors and for four different levels of government is discussed in Section 2. In section 3 we present the descriptive analysis of the most relevant variables. The results of the estimation of different production function specifications are discussed in section 4, while section 5 offers some concluding remarks.

2. Construction of the public capital series

As stated in the introduction, by building on the seminal contribution by Aschauer (1989), the aim of this study is to assess the impact of public intervention in the Italian economy by means of the estimation of Cobb-Douglas production functions in which the public capital stock is included along with the others inputs, such as labour, private capital and other intangible factors which are expected to have a significant effect on the level of production.

The Italian National Institute of Statistics (ISTAT) does not publishes data on the capital stock series at regional level; moreover, for the country as a whole, only data for the total capital stock is provided, without any disaggregation which considers the private or public origin of the funding. Therefore, the first stage of this study focused on the construction of the capital stock series at the regional level and subsequently the decomposition of the total capital series into the stock of private and public capital. Such a disaggregation is crucial in order to disentangle the effect on the production level due to the public sector intervention or due to private enterprises.

The reconstruction of the capital series has been carried out for the period 1996-2003 by applying the perpetual inventory method, which states that the value of the capital stock at time *t* is equal to the value at time *t-1*, augmented by investment and diminished by depreciation, both measured at time *t*.

Although in empirical applications different definitions of capital have been adopted (gross capital stock, net capital stock, fixed capital consumption or gross fixed capital accumulation), we believe that the stock of net capital is an adequate definition as it allows to take into account the decreasing efficiency of the capital goods due to their utilization in the production process. It is worth noting that in the production function specification both output and labour are *flow* variables, while capital is a *stock* variable; this can affect the estimates as the series exhibit different dynamic features. However, given that a capital flow variable (such as capital consumption) is not available, the use of net capital - instead of gross capital - should alleviate the estimation problems (Bonaglia *et al*., 2000).

The capital stock for the year 1995 (i.e. the initial year on which the reconstruction of the series is based, but which will not be included in the estimation period) is represented by the datum provided by ISTAT for the national capital stock at 1995 constant prices. The partition of the national stock among the regions has been carried out by following the methodology proposed in Gleed and Rees (1979) for the British economy and also applied in Paci and Pusceddu (2000) for the Italian context.[2] Total investments data for the subsequent period 1996-2003 are provided by ISTAT in the "Regional Economic Accounts" dataset. All the variables available at current prices are deflated by applying the regional implicit investment deflators.

The crucial key element in the methodology adopted is clearly the definitions of "public investments" which are represented by the capital account public expenditures of the entire public sector provided in the CPT database.[3] In this way we are including not only the capital goods which are explicitly owned by public administrations or institutions, but also the portion of private investment which has been undertaken only thanks to the public funding in the form of firms' transfers. This wide definition of public investments allows, for the first time in Italy, to assess thoroughly the effects of public intervention in the economic system. Thus, the private component has been obtained as the difference between total and public investments. Moreover, the total depreciation published by ISTAT for the whole national stock of capital has been attributed to the

[2] In particular, the regional subdivision is based on the regional average share of investments (weight 0.75) and labour units (weight 0.25) in the preceding 15 years.

[3] In constructing the series we focused on the components compatible with the National Accounts, namely "investment expenditure" and "capital account transfers". We have therefore intentionally excluded all financial entries (i.e credits and share capital quotas). In this paper we use data from the release of March 2006.

public and the private component on the basis of the investment quotas.[4] Finally, the total capital stock in the initial year 1995 has been disaggregated into its public and private components on the basis of the average shares in the subsequent years, 1996-2003. This amounts to assume implicitly that the composition of the aggregate stock do not change significantly in the period considered, so that the information embodied in the 1996-2003 data can be employed to calculate the public and private quotas in the initial year[5].

Following the same methodology, we have then obtained the series of the public capital stock disaggregated in four economic macro-sectors - economic infrastructures, human capital infrastructures, social infrastructures and housing - and into four levels of government - central public administration, regional administrations, local administrations and other central administrated public bodies.

Finally, it is worth underlining that the perpetual inventory method, which allows calculating the monetary value of the capital account public expenditure, may present some drawbacks. If public expenditure is not completely "converted" into productive infrastructures actually utilized in the economy; this can lead to overestimating the capital stock in those regions which are less efficient in the use of public funds. Thus, an alternative approach is to include in the production function indices of the realized physical infrastructures. However, such an approach turns out to be inadequate if the interest is on measuring the effectiveness of the total expenditure of the public sector. Indeed, to obtain a correct estimate of the impact of public capital it is crucial to take into account all public resources, which have not only been directly transformed into a physical infrastructure, but - in the form of financial incentives to firms - have also created the conditions to start a new private investment. The broad definitions of the CPT capital account series actually allow to assess how the public sector intervention has enhanced production and efficiency in the Italian economy.

3. Data analysis

In this section we describe the series used in our empirical analysis. In Table 1 and Map 1 we report some summary statistics of the variables included in the estimation. The entries refer to the

[4]Note that for the whole period considered, the depreciation, equal to 4% of the previous year capital stock, amounts to around 70% of gross investments. Such a relevant share of depreciation on gross investment means that on average net investment is just 2% of the total stock of capital.

[5] In order to assess the robustness of such an hypothesis we have also calculated the share of public capital on total capital stock as equal to the "Public Administration" sector, published in the ISTAT National Accounts. The results do not change appreciably, so the subsequent analysis is based on the methodology described above.

Italian regions[6], to two macro-areas, namely Centre-North, Mezzogiorno (the Southern regions of the country[7]) and to the national aggregate. All the values are calculated as index numbers with respect to the national average over the period 1996-2003. In the first part of the table we show the per capita values for gross domestic product, research and development (R&D), human capital and social capital, while the second part of the table reports the share of public over total capital stock and some summary measures for the public stock of capital, namely index numbers for per capita, per unit of labour and per square kilometre values.

From the per capita GDP data it is evident that all the Mezzogiorno regions are well below the national average, confirming the permanent economic divide between the Centre-Northern and the Southern parts of the country; it is worth noting that during the period 1996-2003 the Mezzogiorno has grown at an average annual rate of 2%, which is higher with respect to the Centre-North rate of 1.4%; however, much higher and persisting growth rates would be required in the Southern region to fill the gap in per capita GDP.

The three subsequent columns in Table 1 and panels 2-4 in Map 1 report index numbers for three important intangible inputs to be included in the production function regressions, namely R&D, human capital and social capital.

The R&D proxy is represented by the number of workers employed in research and development activities for 1000 inhabitants; human capital is proxied by the percentage of workers that have attained at least a university degree. The choice of a proper indicator for an intangible and complex element like social capital is a very difficult task. In this paper we are using an indicator taken by an annual social survey held by ISTAT (Indagine multiscopo) defined as the number of people (per 100 inhabitants over 14 years old) that have taken part at least once in the last twelve months in social activities such as voluntary service, unions and cultural associations meetings [8].

Human capital does not show relevant differences between the Centre-Northern and the Southern regions as the annual averages are quite close to the national one. On the other hand, the R&D and the social capital proxies show a clear dualistic pattern across the regions. In the case of R&D the Mezzogiorno average is about half of the national one, while the Centre-North has an average which is 26% higher with respect to the country one and 2.4 times as higher as the Southern

[6] In this study the region of Val d'Aosta is aggregated to Piemonte, as for its very small size it often exhibits peculiar values.

[7] The regions included in the Mezzogiorno aggregate are: Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna.

[8] Alternatively, as a social capital proxy we have also considered the "political participation" (measured as number of people that have take part at least once in the last twelve months in political associations events) and the "crime risk perception rate" (measured as the proportion of families that consider the area in which they live as insecure). The inclusion of these alternative proxies for social capital did not change appreciably the regression results presented below.

one. The social capital shows a less dramatic difference, but the gap between the Mezzogiorno and the Centre-North is still highly significant, as the two areas are 44 percentage points apart.

Considering the crucial role that intangible infrastructures, such as human capital, social capital and R&D activity play in enhancing the development process and in reducing the gap between poor and prosperous regions, the data discussed above are particularly worrying and call for prompt and decisive policies capable of modifying permanently the current pattern, an unequivocal cause/consequence of the Italian dualistic growth dynamics.

Before turning to the analysis of public capital data, it is important to highlight that the accumulation of the total stock of capital has grown much rapidly in the Centre-North (2.1% on average) than in the Southern regions, where the annual growth rate was just 1.7% over the period 1996-2003. Table 1 highlights an important point, the public component of the total stock of capital is much more relevant in the Mezzogiorno, where it reaches an average share of 39%, which contrasts sharply with the Centre-North share of 23%; four Southern regions out of eight show a share higher than 40% (see also panel 6 in Map 1). In the case of Lazio – where all the Ministries and most of the central administrations have their headquarters - it is important to note that part of the public capital stock attributed to this region might reasonably be due to public investment that cannot be regionalized.

Focusing on the public stock of capital, the per capita values and the unit of labour values are higher in the Mezzogiorno when compared to the national average; this, *ceteris paribus* and excluding crowding out effects, is expected to lead to higher labour productivity.

The following tables 2-3 show the percentage shares of the different categories of infrastructures and levels of government in which the total stock of public capital can be decomposed. The four kinds of infrastructures are economic infrastructures (transport, telecommunications, environment, waste, water, energy, agriculture, fishing, industry, tourism and other services), human capital infrastructures (buildings and facilities for education, training, R&D, work and social security); social infrastructures (buildings and facilities for cultural activities, health services, sanitation, defence, justice administration, public security and general administration) and housing.

As shown in the second column of Table 2, economic infrastructures are the most relevant public capital component, with a share of 65% for the national aggregate, which increases considerably in the Mezzogiorno (67.6%). In the Mezzogiorno higher shares are also associated with the “housing” component (9.1% with respect to 8% in the Centre-North). On the other hand, the Southern regions show lower shares for both human capital (7.7% with respect to 8.5% in the Centre-North). and social capital kind of infrastructures (15.5% vs 20.4%).

The data on human capital and social capital infrastructures mirror the patterns discussed above for their "intangible" counterparts; therefore, it seems necessary to complement the policies designed to support a faster accumulation of human and social capacities with an increase in the level and effectiveness of public investments for infrastructures in the same fields.

Finally, in Table 3 we report the percentage shares of the public stock of capital for the four different types of administrations which deliver the funds. As expected the central State administration is the most relevant one for all the Mezzogiorno regions with share of 32%. The other central administrated public bodies have a national average of 29%, which turns out to rise considerably in the Centre-North (33.5%) with respect to the South (23%). It is important to notice that the relevant role played by these public institutions (like the electrical national company, the national postal service, the national railway, the national energy company) in providing public capital has been neglected in previous studies. The regional administration shows a similar pattern with a Mezzogiorno share of 19% and a Centre-North one of just 14.4%. On the other hand, the local administrations exhibit a reversal composition with an higher share in the Centre-North (30.7%) with respect to the Mezzogiorno (25.7%). Regional and local administrations together account for almost half of total public investment expenditures and therefore its level of efficiency in delivering these large amount of public resources is an important issue to be addressed.

4. Production function estimations for Italy and the macro regions

The effects of public investment in Italy over the period 1996-2003 are assessed by estimating different Cobb-Douglas production function specifications. The empirical analysis is articulated by considering different levels of disaggregation for the total stock of capital.

The general model is reported below:

$$Y_{it} = A_i L_{it}^{\alpha} K_{it}^{\beta} \prod_{j=1}^{J} X_{j,it}^{\gamma_j}$$

where Y is regional value added in 1995 base constant prices (excluding the financial intermediation services), L are units of labour, X is a set of J control variables (with j=1,2,3); in our study these are represented by the "intangible" inputs, namely research and development (*RD*), human capital (*HK*) and social capital (*SK*). A represents the efficiency level; the parameters α and γ_j are the output elasticities (or semi-elasticities) with respect to each of the inputs. The subscript i indicates the region, while t refers to the time period. Finally, K is the stock of capital which takes the following forms depending on the disaggregation considered:

$$K_{it}^{\beta} = Ktotal_{it}^{\beta_1}$$
$$K_{it}^{\beta} = Kprivate_{it}^{\beta_2} * Kpublic_{it}^{\beta_3}$$
$$K_{it}^{\beta} = Kprivate_{it}^{\beta_2} * K(economic\_infr)_{it}^{\beta_4} * K(other\_infr)_{it}^{\beta_5}$$
$$K_{it}^{\beta} = Kprivate_{it}^{\beta_2} * K(central\_adm)_{it}^{\beta_6} * K(decentr\_adm)_{it}^{\beta_7}$$

the βs coefficients measure the capital elasticities with respect to output.

Once transformed by taking natural logarithms, each specification of the general model is estimated by employing a panel of 19 regions and 8 annual observations over the period 1996-2003; this can be considered a "small" panel, since both the cross-section and the time dimension are rather short. In this case the estimation results have to be interpreted very cautiously.

In line with previous studies on production function estimation (see among others, Garcia-Milà et al., 1996), we start the analysis by dealing with the issue of potential endogeneity and the presence of measurement errors for all productive inputs; this is carried out by applying the well known Durbin-Wu-Hausman (DWH) test[9]. For all the specifications considered in this study the test indicates that we have to reject the null hypothesis of exogeneity and, consequently, we have to resort to the instrumental variable (IV) estimation method. In all the estimated models, following the procedure usually applied within the production function framework, each variable is instrumented by its own one-year lagged values.

Due to the panel dimension in the estimated regression we do not include regional fixed effect, but an additive and a multiplicative dummy variable "South", which is supposed to capture the time-invariant different characteristics of the Centre-North and the Mezzogiorno macro-areas. We also include time dummies and a dummy "Lazio", which should offset the effects of the non-regionalized funds. Moreover, regional heterogeneity is treated by applying the feasible GLS method with cross section weights, which accounts for potential heteroskedasticity. All the IV-GLS estimation results are presented in Table 4[10], to ease the comparisons in Table 5 we report the results for the two macro-regions separately.

4.1 Total capital stock

In the first specification, which is the simplest one, the capital input is considered in the aggregate; by taking logs the general model is transformed in the following estimation model:

[9] For a detailed discussion on the DWH test see Davidson and MacKinnon (1993). Note also that if we had longer time series data we could also test for endogeneity and reverse causality within the cointegration framework by testing for weak exogeneity of all the variables included in the system.

[10] Note that the reported standard errors are White heteroskedasticity consistent standard errors.

$$y_{it} = a_i + \alpha l_{it} + \beta_1 ktotal_{it} + \gamma_1 rd_{it} + \gamma_2 hk_{it} + \gamma_3 sk_{it} + \varepsilon_{it} \quad (1)$$

The first column of Table 4 shows the estimation results for the regression model above without including the additive and multiplicative dummy "South", so that this model can be seen as a sort of *national benchmark* which allows to assess regional differences in the estimated input elasticities. According to specification (1) the elasticity of labour is around 0.73, while the total stock of capital exhibits an elasticity of 0.29. Both elasticities are similar to those reported in previous studies for the Italian case (Picci, 1999, La Ferrara and Marcellino, 2000). Innovation activity and social capital show elasticities estimated in 0.10 and 0.12, respectively. In the case of human capital the estimate obtained (0.014) is a semi-elasticity as it measures the percentage increase in output due to an increase of 1 percentage point in the proportion of graduate workers. It is worth stressing that all the "intangible" factors exhibit a positive and significant coefficient, confirming their relevant contribution to the production process.

In the second specification the dummy "South" is included in order to assess the existence of differences in the effect of production factors between Centre-northern and Southern regions:

$$y_{it} = a_i + \alpha l_{it} + \beta_1 ktotal_{it} + \gamma_1 rd_{it} + \gamma_2 hk_{it} + \gamma_3 sk_{it} + dummies + \varepsilon_{it} \quad (2)$$

The results for this specification (column (2) in table 4) indicate that the only inputs that exhibit elasticities homogeneous across the country macro-areas are labour (0.68) and human capital (0.008); the elasticity of the total stock of capital decreases significantly from the Centre-North values of 0.36 to the Mezzogiorno one of 0.29; a similar result is found for the social capital input as well, the estimated impact is 0.039 for the Centre-Northern macro-area and -0.11 for the South; note that the social capital impact appear to have even an adverse effect on the South production level. On the other hand, the R&D input (0.041 vs 0.067) turns out to be more productive in the Southern part of the country; this is presumably due to the fact that in the Mezzogiorno there is just half of the employees in the R&D sector with respect to the national average.

4.2 Specification including private and public capital stock

In specification (3) we introduce the disaggregation of the stock of capital into its private and public components:

$$y_{it} = a + \alpha l_{it} + \beta_2 kprivate_{it} + \beta_3 kpublic_{it} + \gamma_1 rd_{it} + \gamma_2 hk_{it} + \gamma_3 sk_{it} + dummies + \varepsilon_{it} \quad (3)$$

This specification is crucial in order to estimate the effect of the public stock of capital on the country productivity. As discussed above, also in this case we include the additive and

multiplicative dummy "South" in order to assess thoroughly the disparities between the Centre-Northern and the Southern areas, which can lead to misspecification problems if they are overlooked.

From specification (3) it is important to highlight the significant positive sign associated with the public capital stock which confirms the results of the previous literature on the positive role played by the public expenditures on the production level. The elasticity of the public stock of capital with an estimated value of 0.12 does not show significant differences between the Centre-North and the Mezzogiorno, but it is much lower compared to previous analyses (Picci, 1999; La Ferrara and Marcellino, 2000; Marrocu *et al*., 2001; Paci and Saddi, 2002); however, it is worth keeping in mind that such studies focused on periods characterised by a very speed process of capital accumulation, especially in the Mezzogiorno.

Turning to the other productive inputs, it is evident that their impact differs considerably when the geographic pattern is accounted for. In particular, the labour is much less productive in the South (the estimated elasticity decreases from the Centre-North value of 0.81 to the value of 0.42 for the South). On the other hand, the private capital stock turns out to be three times more productive in the Mezzogiorno. Focusing on the "intangible" inputs, for this specification the R&D variable shows an elasticity of 0.051 which is homogeneous across the country. On the contrary, human capital and social capital show a significant negative impact in the South. In the case of human capital this result might be due to the fact that in Southern regions a considerable proportion of the graduated labour force holds a degree in fields such as humanities or law, which are supposed to have a limited effect on production; on the other hand, in the Centre-North there is evidence of a greater proportion of workers with a degree in scientific and technological fields (engineering, science, medicine, informatics). The negative impact of social capital – consistently found in the other specifications as well – is reasonably capturing the lower level of general trust and confidence in the South, which is supposed to have a severe adverse effect on the firms' investment and location decisions.

4.3 Public capital stock disaggregated into macro-sectors

In this section we discuss the results obtained when the stock of public capital is disaggregated according to different kinds of infrastructure (or public intervention macro-sectors). We recall that the reconstruction of the public capital stock has been carried out for four sub-aggregates, namely economic infrastructures (*ec_infr*), human capital infrastructures, social capital infrastructures and housing. However, in order to simplify the analysis the last three typologies of public capital (which

on average sums up to 35% of total public capital) have been grouped together (*other_infr*). The regression model is reported below:

$$y_{it} = a + \alpha l_{it} + \beta_2 kprivate_{it} + \beta_4 k(ec\_infr)_{it} + \beta_5 k(other\_infr)_{it} + \gamma_1 rd_{it} + \gamma_2 hk_{it} + \gamma_3 sk_{it} + dummies + \varepsilon_{it} \quad (4)$$

Specification (4) confirms the previous results with the labour factor showing a lower elasticity in the Mezzogiorno (0.63 vs 0.83), while the private capital stock elasticity is lower in the Centre-North (0.12 vs 0.26).

The stock of public capital exhibits quite different elasticities for the two categories considered and for the two macro-areas of the country. More specifically, the economic infrastructures, which account for the largest proportion of the public stock, are much more productive in the Mezzogiorno (0.28) compared to the rest of the country (0.10). In contrast, all the other types of public interventions show a negative impact in the Mezzogiorno (-0.064) and basically no effect in the Centre-North. These results are of great interest for at least two reasons. Firstly, they point out that it is important to consider the composition of the public capital stock, as when it considered in the aggregate no significant differences seem to emerge between the two macro-areas. Secondly, the estimated coefficients highlight the beneficial impact of the most production-oriented kind of infrastructures in the Southern regions and emphasize the need to focus even more on public policies intended to tackle the productive structure of the economic system. Such policies should be designed to guarantee at the same time an increased level of the national production and a permanent reduction in the regional disparities.

For this particular specification, the R&D impact in the South (0.086) is more than twice as large as the one for the Centre-North (0.037); this result can be interpreting considering the low proportion of R&D workers in the South, which can yield to increasing returns to this specific factor. The human capital coefficient turns out to be constant all over the country with an estimated semi-elasticity of 0.004. Social capital, on the other hand, continues having a quite negative effect (-0.12) in the Mezzogiorno, while it turns out to enhance production levels in the Centre-North.

4.4 Public capital stock disaggregated into levels of government

The results shown in the last column of table 4, obtained from the estimation of a production function relationship in which the stock of public capital enters disaggregated according to levels of government, allow evaluating the efficiency of the different administrations in charge for the delivering of public funds.

In order to simplify the econometric analysis the four kinds of administration have been grouped into two main categories, the central level (central administration and the other central

administered public bodies, *central_adm*) and the decentralized level (regional and local administrations, *decentr_adm*), this results in the following regression model:

$$y_{it} = a + \alpha l_{it} + \beta_2 kprivate_{it} + \beta_6 k(central\_adm)_{it} + \beta_7 k(decentr\_adm)_{it} + \gamma_1 rd_{it} + \gamma_2 hk_{it} + \gamma_3 sk_{it} + dummies + \varepsilon_{it} \quad (5)$$

Specification (5), by providing further evidence on how the inputs' impacts differ across macro-regions, supports the previous results regarding the estimated effects for labour (lower in the Mezzogiorno), private capital (lower in the Centre-North) and R&D (higher in the Mezzogiorno). The only exception is represented by social capital which, for this particular specification, seems to have the same negative effect both in the Centre-North and in the Mezzogiorno.

As far as the public capital stock is concerned, it is important to highlight that in the Mezzogiorno the regional and local administrations are much less efficient in delivering public funds, as the estimated elasticities turns out to be significantly lower with respect to the Centre-North (0.017 vs 0.075). Central administrations, on the other hand, exhibit the same degree of efficiency across the macro-areas (0.043).

The very low value estimated for the South is rather worrying as it signals the incapacity of the local governments of exploiting the informative advantages due to the proximity to the economic and social structure; such advantages are expected to make more effective the beneficial impacts of public investments in the poorest regions of the country.

5. Conclusions

This study aims to evaluate the effects of public capital stock on the level of production. Such an assessment is rather relevant considering the crucial role played by public investments in Italy and Europe to enhance economic growth and development, in particular in the poorest regions. The economic resources devoted to increase the physical and intangible infrastructure endowment are an important component of the national stock of capital and are a key factor for economic growth.

The effects of the public capital stock have been measured by estimating production functions relationships in which it is included among other inputs, such as labour, private capital stock and intangible factors. The series of public capital – and their disaggregation into different infrastructure components or according to various government levels delivering the funds – have been reconstructed by using the data on capital account public expenditure of the recently published CPT database (Department for Development and Cohesion Policies of the Italian Ministry of Economy and Finance).

For the first time in Italy, on the basis of the CPT database it is possible to obtain a comprehensive and reliable estimate of the contribution of the whole public sector to the

accumulation of the national stock of capital. Indeed, the CPT series allow describing a complete picture of the public investment expenditures delivered by all public institutions, or by institutions operating within a public context and, at the same time, to measure more accurately the contribution of the public sector to the economic growth process at regional level. However, it is worth noting that the short period of time available calls for a cautious interpretations of the results provided, as they can be affected by the period considered.

Different specifications of Cobb-Douglas production functions for Italy over the period 1996-2003 have been estimated using instrumental variable method to account for the presence of endogeneity for the production inputs.

The first result is that, once one controls for the effects of intangible inputs (R&D, human and social capital) public capital stock play unequivocally a positive role in fostering the level of production. Although the estimated elasticity is lower compared to previous studies for the Italian case, it is important to stress that even in the most recent years when the speed of capital accumulation has considerably decreased, the public intervention in still a key factor in determining the country production level.

The second relevant result concerns the different impact that the productive inputs have on the economy of the two macro-areas of the country, thus providing further evidence on the dualistic character of the national economic structure. In particular, the results show that while labour is less productive in the South, private capital has a lower impact in the Centre-Northern regions.

The analysis of the effects of the stock of public capital is further articulated by considering its different components and the disaggregation into levels of government. The most relevant outcome points out that economic infrastructures are much more productive in the South, while the other types of public infrastructure seem to play a very limited role. This result call for even greater efforts in implementing and designing policies aimed at increasing the national level of production and, at the same time, at reducing the regional disparities permanently.

Finally, a noteworthy result comes up from the disaggregation of the public capital into levels of government. It turns out that in the Mezzogiorno the regional and local administrations are much less efficient in delivering public funds. The very low coefficient estimated for the South is rather worrying as it signals the failure of the local governments in exploiting the informative advantages due to the proximity to the economic and social structure in order to make more effective the beneficial impacts that public investments are expected to produce in the poorest regions of the country.

This failure is even more distressing for the future given the process of fiscal federalism which will grant more power and responsibilities to local administrations for the management of public

expenditures. In this respect, our results suggest the importance of promoting regional growth in the lagged regions not only providing public capital but also through a more general reform of the local public administrations in the South.

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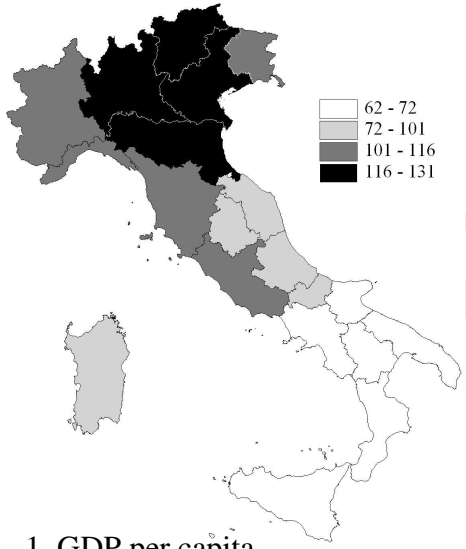
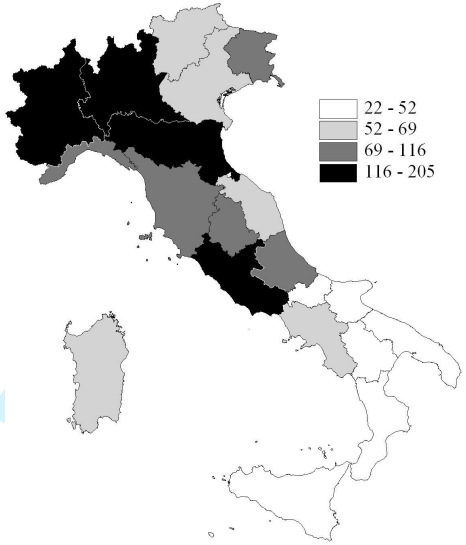
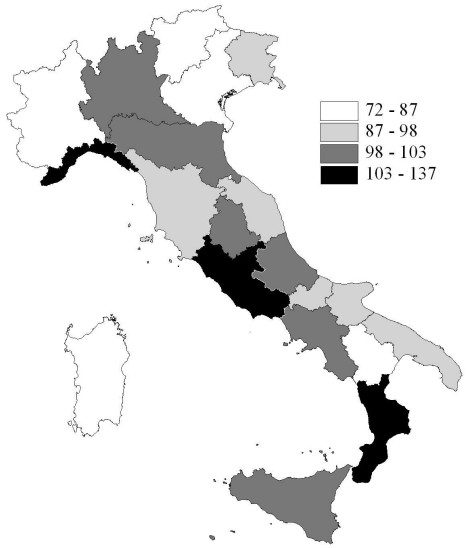
Map 1. Regional distribution of main variables.
Average values 1996-2003. Panel 1-5: indices, Italy = 100. Panel 6: % shares on total capital



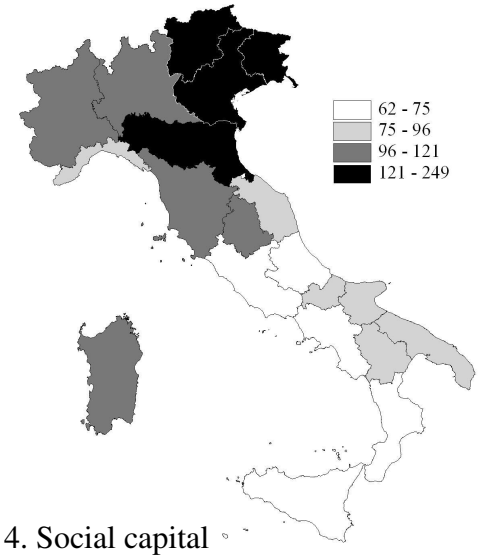
1. GDP per capita



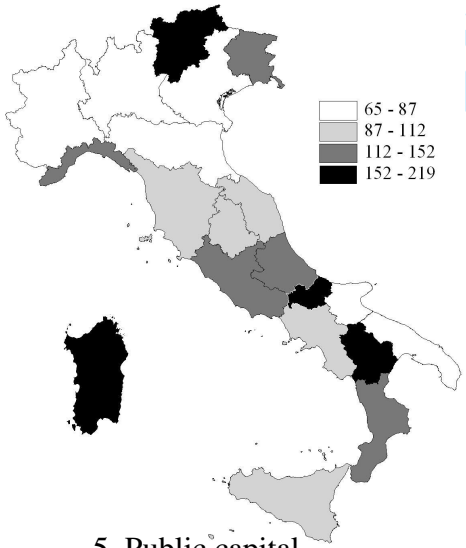
2. R&D



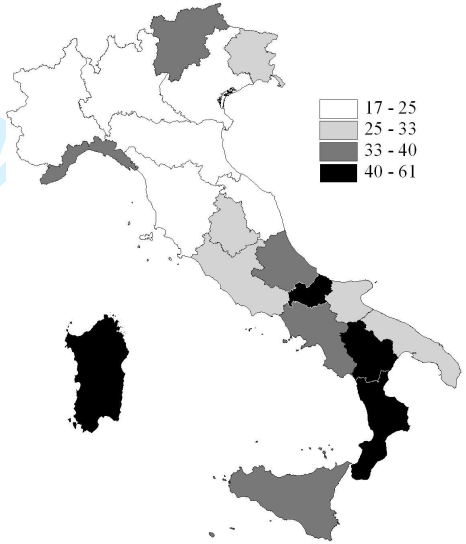
3. Human capital



4. Social capital



5. Public capital



6. Public capital shares

Table 1 – Descriptive Statistics, Indices *(Italy=100, average values 1996-2003)*

	Per capita GDP[1]	R&D[2]	Human capital[3]	Social capital[4]	Share of public stock on total stock, %	Public capital stock		
						per capita	per labour unit	per km^2
Piemonte+Val D'Aosta	116	156	87	102	22	87	79	69
Lombardia	130	129	103	121	17	69	59	138
Liguria	108	116	115	87	38	152	150	236
Trentino A.A.	131	69	72	249	40	210	165	76
Veneto	117	67	82	151	17	65	56	84
Friuli V.G.	114	116	93	139	31	138	124	109
Emilia R.	126	127	103	122	21	80	65	75
Toscana	110	101	94	110	25	88	78	70
Umbria	97	93	101	103	33	112	110	58
Marche	101	62	98	96	25	88	81	70
Lazio	110	205	137	70	30	121	117	192
Abruzzo	86	87	101	75	37	127	136	79
Molise	79	29	96	83	49	191	222	74
Campania	64	67	100	63	39	111	150	246
Puglia	66	42	93	77	30	78	98	85
Basilicata	72	41	75	80	61	219	280	69
Calabria	62	22	105	72	44	127	169	90
Sicilia	67	52	102	62	36	101	140	104
Sardegna	76	59	82	105	50	172	202	62
Centre-North	118	126	101	115	23	92	82	100
Mezzogiorno	68	53	97	71	39	114	148	101
Italy	100	100	100	100	28	100	100	100

[1] *GDP*, *population* and *labour units* are from the CRENoS database on the Italian regions.

[2] *R&D* is defined as the number of workers employed in R&D activities for 1000 inhabitants (*source*: ISTAT, Statistics on the Scientific Research).

[3] *Human capital* is defined as the percentage of the labour force that has attained at least a degree (*source*: ISTAT, Labour force survey).

[4] *Social capital* is defined as the number of people that have taken part at least once in the last twelve months in social activities such as voluntary service, unions and cultural associations meetings (*source*: ISTAT, Multiscopo survey).

Table 2 – Public capital stock per macro-sectors
(percentage shares, average values 1996-2003)

	Economic infrastructures	Human capital infrastructures	Social infrastructures	Housing
Piemonte+Val D'Aosta	65.1	8.1	20.7	6.1
Lombardia	61.4	9.5	20.7	8.4
Liguria	69.3	6.1	16.7	7.9
Trentino A.A.	59.3	8.2	24.1	8.5
Veneto	60.0	7.0	25.7	7.3
Friuli V. G.	60.8	7.1	21.2	10.9
Emilia R.	62.6	7.8	23.1	6.4
Toscana	63.5	9.2	20.3	7.0
Umbria	57.0	5.9	19.5	17.6
Marche	57.8	7.0	24.7	10.5
Lazio	66.5	10.4	15.5	7.6
Abruzzo	63.6	9.0	18.4	9.0
Molise	70.3	8.5	15.2	6.0
Campania	67.2	7.8	14.6	10.5
Puglia	68.8	7.6	14.5	9.2
Basilicata	69.5	6.1	16.6	7.9
Calabria	67.3	8.3	15.3	9.1
Sicilia	68.0	7.8	15.0	9.2
Sardegna	68.0	7.0	17.7	7.2
Centre-North	63.1	8.5	20.4	8.0
Mezzogiorno	67.6	7.7	15.5	9.1
Italy	65.0	8.2	18.4	8.5

Table 3 – Public capital stock per levels of government
(percentage shares, average values 1996-2003)

	Central Administration	Other central administered public bodies	Regional Administration	Local Administration
Piemonte+Val D'Aosta	20.9	30.4	18.1	30.6
Lombardia	20.4	31.8	12.4	35.4
Liguria	25.0	36.0	8.7	30.4
Trentino A.A	4.7	11.7	50.3	33.3
Veneto	20.2	29.2	15.7	34.9
Friuli V. G.	15.3	30.5	22.8	31.4
Emilia R.	18.1	38.0	13.4	30.5
Toscana	18.2	37.8	11.3	32.7
Umbria	26.6	21.7	15.3	36.5
Marche	19.0	28.6	16.7	35.7
Lazio	31.2	44.3	4.0	20.4
Abruzzo	30.8	29.2	16.9	23.1
Molise	33.1	16.4	24.8	25.7
Campania	36.0	25.2	10.7	28.1
Puglia	39.1	24.1	11.3	25.5
Basilicata	34.1	23.2	19.9	22.8
Calabria	36.2	17.6	23.4	22.8
Sicilia	26.0	23.4	23.5	27.1
Sardegna	23.6	18.9	33.8	23.8
Centre-North	21.3	33.5	14.4	30.7
Mezzogiorno	32.2	23.0	19.0	25.7
Italy	25.8	29.2	16.3	28.6

Table 4 Estimation of the production function for Italy

Dependent variable: value added at 1995 constant prices
Method: IV/GLS (Cross Section Weights); the instruments are the one-year lagged values of the variables themselves.
Sample: 1996 2003; Included observations: 8; Number of cross-sections used: 19
Total panel (balanced) observations: 133; *White consistent standard errors* in parentheses

Regressors	(1)	(2)	(3)	(4)	(5)
constant	1.400 [a]	1.291 [a]	1.886 [a]	2.122 [a]	1.717 [a]
	(0.240)	*(0.056)*	*(0.192)*	*(0.128)*	*(0.122)*
labour	0.730 [a]	0.684 [a]	0.807 [a]	0.828 [a]	0.731 [a]
	(0.035)	*(0.008)*	*(0.027)*	*(0.019)*	*(0.025)*
total capital stock	0.295 [a]	0.365 [a]			
	(0.038)	*(0.008)*			
- private capital stock			0.139 [a]	0.117 [a]	0.151 [a]
			(0.025)	*(0.021)*	*(0.016)*
- public capital stock			0.119 [a]		
			(0.006)		
• economic infrastructures				0.095 [a]	
				(0.015)	
• other infrastructures				0.011	
				(0.008)	
• central administr. capital					0.043 [a]
					(0.006)
• regional and local administr. capital					0.075 [a]
					(0.004)
R&D	0.105 [a]	0.041 [a]	0.051 [a]	0.037 [a]	-0.015 [a]
	(0.006)	*(0.005)*	*(0.011)*	*(0.005)*	*(0.006)*
human capital	0.014 [a]	0.008 [a]	0.006	0.004 [c]	0.005 [b]
	(0.003)	*(0.002)*	*(0.006)*	*(0.002)*	*(0.002)*
social capital	0.118 [a]	0.039 [a]	0.045 [b]	0.030 [b]	-0.023 [c]
	(0.005)	*(0.010)*	*(0.021)*	*(0.014)*	*(0.014)*
dummy South		1.134 [a]	--	--	--
		(0.073)			
South*(labour)		--	-0.386 [a]	-0.202 [a]	-0.262 [a]
			(0.038)	*(0.020)*	*(0.019)*
South*(total capital stock)		-0.071 [a]			
		(0.002)			
- South*(private capital stock)			0.295 [a]	0.143 [a]	0.241 [a]
			(0.038)	*(0.022)*	*(0.021)*
- South*(public capital stock)			--		
• South*(economic infrastructures)				0.185 [a]	
				(0.043)	
• South*(other infrastructures)				-0.075 [a]	
				(0.010)	
• South*(central administration capital)					--
• South*(regional + local administration capital)					-0.058 [a]
					(0.005)
South*(R&D)		0.025 [b]	--	0.048 [a]	0.063 [a]
		(0.011)		*(0.010)*	*(0.007)*
South*(human capital)		--	-0.026 [b]	--	-0.013 [a]
			(0.012)		*(0.005)*
South*(social capital)		-0.151 [a]	-0.198 [a]	-0.150 [a]	--
		(0.020)	*(0.018)*	*(0.028)*	

Note: dummy "South" assumes value 1 for the eight Southern regions and 0 for the remaining regions; time dummies and a dummy for the Lazio region are included in all specifications.

All estimated coefficients are elasticities with the exception of the "human capital" one which is a semi-elasticity (see text for details).

Significance levels: a = 1%, b=5%, c=10%

Table 5 Estimated coefficients of the production function for Italian macro-regions

Dependent variable: value added at 1995 constant prices; 1996-2003			
Specification	Regressors	Centre-North	Mezzogiorno
(2)	constant	1.291	2.425
	labour	0.684	0.684
	total capital stock	0.365	0.294
	R&D	0.041	0.067
	human capital	0.008	0.008
	social capital	0.039	-0.112
(3)	constant	1.886	1.886
	labour	0.807	0.421
	private capital stock	0.139	0.434
	public capital stock	0.119	0.119
	R&D	0.051	0.051
	human capital	0.006	-0.019
	social capital	0.045	-0.153
(4)	constant	2.122	2.122
	labour	0.828	0.626
	private capital stock	0.117	0.260
	public capital stock		
	• econ. infrastructures	0.095	0.280
	• other infrastructures	0.011	-0.064
	R&D	0.037	0.086
	human capital	0.004	0.004
	social capital	0.030	-0.121
(5)	constant	1.717	1.717
	labour	0.731	0.469
	private capital stock	0.151	0.391
	public capital stock		
	• central administrations	0.043	0.043
	• regional and local administrations	0.075	0.017
	R&D	-0.015	0.048
	human capital	0.005	-0.008
	social capital	-0.023	-0.023
Time dummies and a dummy for the Lazio region are included in all specifications.			